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# Final Status Report

## Multiwavelength Monitoring of the Superluminal Quasar 3C 279

### NASA Grant NAG5-2154

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Period Covered: December 1992 through March 1996

This is a final report to the National Aeronautics and Space Administration (NASA) concerning NASA grant NAG5-2154. This grant was awarded to Dr. C. Megan Urry of the Space Telescope Science Institute in response to successful IUE proposals to carry out "Multiwavelength Monitoring of the Superluminal Quasar 3C 279." Some of the work on this project was carried out by two post-docs, Paola Grandi (now at the University of Rome) and Joe Pesce (at STScI), as well as an STScI summer student (Laura Wickless).

The grant was originally awarded on 12/15/92, with a subsequent award on 3/23/94; this report covers the full period of the grant, through March 1996.

Our monitoring campaign for 3C 279 was extremely successful. It has resulted in a series of refereed and/or submitted papers:

- "3C279 Multiwavelength Monitoring. II. Ground-Based Campaign" 1996, P. Grandi, C. M. Urry, L. Maraschi, A. E. Wehrle, G. M. Madejski, M. F. Aller, H. D. Aller, C. D. Bailyn, T. J. Balonek, T. H. Bock, I. S. Glass, S. J. Litchfield, I. M. McHardy, J. S. Mulchaey, H.-P. Reuter, E. I. Robson, A. C. Sadun, W. Sherry, H. Steppe, J. A. Steven, H. Teräsranta, M. Tornikoski, and S. J. Wagner, ApJ, 459, 73
- "The 1993 Multiwavelength Campaign on 3C279. I. The Radio to Gamma-Ray Energy Distribution in the Low State" L. Maraschi, P. Grandi, C. M. Urry, A. E. Wehrle, G. Madejski, H. H. Fink, G. Ghisellini, R. C. Hartman, A. Koratkar, E. Pian, H.-C. Thomas, A. Treves, M. F. Aller, H. D. Aller, C. D. Bailyn, T. J. Balonek, H. Bock, W. Collmar, I. S. Glass, S. J. Litchfield, I. M. McHardy, R. Méndez, J. Pesce, H. P. Reuter, E. I. Robson, H. Steppe, J. A. Stevens, H. Teräsranta, and S. J. Wagner, 1994, ApJ (Letters), 435, L91

- “Variability of the Ly $\alpha$  Emission Line in 3C 279” A. Koratkar, J. E. Pesce, C. M. Urry, and E. Pian, ApJ, submitted

Additional refereed and/or submitted papers are based largely or in part on the results of the 3C279 observations:

- “Variability of AGN” M.-H. Ulrich, L. Maraschi, and C. M. Urry, 1997, ARAA, in press
- “Multi-Wavelength Observations of 3C 273 in 1993-1995” C. von Montigny, H. Aller, M. Aller, F. Bruhweiler, W. Collmar, T. J.-L. Courvoisier, P. G. Edwards, C. E. Fichtel, A. Fruscione, G. Ghisellini, R. C. Hartman, W. N. Johnson, M. Kafatos, T. Kii, D. A. Kniffen, G. G. Lichti, F. Makino, K. Mannheim, A. P. Marscher, B. McBreen, I. McHardy, J. E. Pesce, M. Pohl, E. Ramos, W. Reich, E. I. Robson, K. Sasaki, H. Teräsranta, M. Tornikoski, **C. M. Urry**, E. Valtaoja, S. Wagner, and T. Weekes, 1997, ApJ, in press

The following invited review papers and/or book chapters were based in part on work supported by this grant:

- “Multiwavelength Properties of Blazars” **C. M. Urry**, 1996, in *Proc. of COSPAR Meeting* (Birmingham UK, July 1996), ed. W. F. Welsh, in press
- “Blazars, the Most Violent Active Galaxies” C. M. Urry, 1996, AAAS Annual Meeting and Science Innovation Exposition, 162nd National Meeting of the AAAS, ed. Michael S. Strauss, et al., p. S-48
- “An Overview of Blazar Variability” C. M. Urry, 1996, in *Blazar Variability*, (Proc. Conference in Miami, February 1996), ed. J. Webb, in press
- “Jets in Active Galactic Nuclei” C. M. Urry, 1993, in *Frontiers of Space and Ground-based Astronomy*, ed. W. Wamsteker, M. S. Longair, and Y. Kondo, (Dordrecht: Kluwer), p. 335
- “Multiwavelength Monitoring of Active Galactic Nuclei” C. M. Urry, 1993, *Adv. Space Res.*, 13, 573

In addition, Paola Grandi has published work on a related topic completed while she was partially funded under this grant:

- “Nonthermal Pair Models, Reflection and X-Ray Spectral Variability” P. Grandi, C. Done, and C. M. Urry, 1994, ApJ, 428, 599

My subsequent post-doc, Joe Pesce, has published work on a related topic completed while he was partially funded under this grant:

- “Redshifts of Southern Radio Galaxies” 1995, R. Scarpa, R. Falomo, and J. E. Pesce, A&A, in press
- “Host galaxy and environment of the BL Lacertae Object PKS 0548–322: Observations with subarcsecond resolution” 1995, R. Falomo, J. E. Pesce, and A. Treves, ApJ, 438, L9
- “Environmental Properties of BL Lac Objects” 1995, J. E. Pesce, R. Falomo, and A. Treves, AJ, 110, 1554

Finally, the following papers presented at or submitted for conferences were based on work supported by this grant:

- “Preliminary Report on the January 1996 Outburst of 3C279” A. E. Wehrle, and the Blazar Multiwavelength Consortium (incl. C. M. Urry), 1996 submitted for the High Energy Astrophysics Division of the American Astronomical Society meeting in San Diego, May 1996
- “VLBI Imaging and Multifrequency Variability of 3C279” A. E. Wehrle, S. C. Unwin, A. C. Zook, and C. M. Urry, 1996, in *Blazar Variability*, (Proc. Conference in Miami, February 1996), ed. J. Webb
- “The Doppler Factor and Orientation of 3C 279” A. E. Wehrle, A. C. Zook, S. C. Unwin, C. M. Urry, and D. Gilmore, 1995, BAAS, 26, 1507
- “Changes in the Parsec-scale Radio Structure of 3C279 Before and After a Gamma-Ray Flare” A. E. Wehrle, A. C. Zook, S. C. Unwin, C. M. Urry, and G. Madejski, 1994, in *The Multi-Mission Perspective* (High Energy Astrophysics Division Meeting of the American Astronomical Society, Napa Valley, November 1994), p. 27
- “A Long Term Variability Study of 3C279” P. Grandi, L. Maraschi, A. Treves, C. M. Urry, R. C. Hartman, A. Wehrle, E. Pian, M. F. Aller, H. D. Aller, I. M. McHardy, J. Stevens, and H. Teräsranta, 1994, in *The Multi-Mission Perspective* (High Energy Astrophysics Division Meeting of the American Astronomical Society, Napa Valley, November 1994), p. 106
- “Long Term Variability of 3C279” P. Grandi, L. Maraschi, C. M. Urry, A. E. Wehrle, M. F. Aller, H. D. Aller, I. M. McHardy, R. C. Hartman, E. Pian, J. A. Stevens, H. Terasranta, and A. Treves, 1994, in *Adv. Space Res.*, 15, 23-26
- “The Broad Band Energy Distribution of 3C279 in Low State: Results from the Multifrequency Campaign of January 1993” L. Maraschi, C. M. Urry, P. Grandi, A. Koratkar, G. Madejski, R. C. Hartman, A. Wehrle, C. Bailyn, H. Fink, H.-C. Thomas, A. Treves, E. Pian, and S. J. Wagner, 1993, BAAS, 25, 1383

- “VLBI Images of 3C279 During the Multiwavelength Campaign in 1992/1993” A. E. Wehrle, S. C. Unwin, A. C. Zook, G. Madejski, L. Maraschi, and C. M. Urry, 1993, BAAS, 25, 1450
- “Multifrequency Observation of the Optically Violent Variable Quasar 3C 279: Ground-based Campaign” P. Grandi, C. M. Urry, L. Maraschi, G. Madejski, R. C. Hartman, A. Wehrle, M. F. Aller, H. D. Aller, C. Bailyn, W. Sherry, T. Balonek, R. Falomo, A. V. Filippenko, I. S. Glass, I. McHardy, J. Steven, S. Lichfield, J. Mulchaey, J. Pesce, A. Sadun, H. Steppe, H.-P. Reuter, H. Terasranta, M. Tornikoski, H. Bock, and S. J. Wagner, 1993, BAAS, 25, 1450
- “Multifrequency Campaign for the Optically Violent Variable Quasar 3C279: X-Ray Observations” G. Madejski, R. Hartman, G. Reichert, A. Wehrle, C. M. Urry, P. Grandi, L. Maraschi, H. Fink, and H.-C. Thomas, 1993, BAAS, 25, 1450
- “Star Formation in Normal and Barred Cluster Spirals” 1995, C. Moss, M. Whittle, J. E. Pesce, and H. Navaro, *Astrophysical Letters and Communications*, 31, 215
- “The cluster environment of BL Lac Objects” 1994, R. Falomo, J. E. Pesce, ESO Messenger, 78, 30

Funds from this grant have been used to support post-doc and summer student salaries, as well as travel to scientific meetings to present results as listed above. Although work under this grant has been completed, related work continues under alternative support, including investigation of the UV, X-ray, and gamma-ray variability data from monitoring campaigns in 1993-4, 1994-5, and 1996.

**FINAL PATENT/INVENTION REPORT**

**Grant:** NAG5-2154

**Principal Investigator:** Dr. C. Megan Urry

**Institution:** Space Telescope Science Institute

**Patents/Inventions Developed:** NONE